Report

Underground Facilities and Infrastructure

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8 October 2020

Underground Facilities and Infrastructure Frontier

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Jeter Hall (SNOLAB)

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Topical Group		**Topical Group co-Conveners and Liaisons**			
		Co-conveners			Liaisons
UF01	Underground Facilities for Neutrinos	Accelerator Neutrinos Tim Bolton	0νββ Patrick Decowski Danielle Speller		Neutrinos Albert de Roeck Astronomical ν Gabriel Orebi Gann
UF02	Underground Facilities for Cosmic Frontier	LXe DM Kaixuan Ni Low Mass Scott Hertel	LAr DM Emilija Pantic		Particle DM Hugh Lippincott Jodi Cooley Instrumentation Eric Dahl
UF03	Underground Detectors	Gravity Waves Laura Cadonati			Instrumentation Frontier Maurice Garcia-Sciveres
UF04	Supporting Capabilities	Radon Richard Schnee	Cleanliness Alvine Kamaha	Low Background Assay Brianna Mount	
UF05	Synergistic Research	Nuclear Astrophysics Daniel Robertson	Geo-microbiology TBD	Geo-engineering TBD	QIS, QC Maurice Garcia-Sciveres
UF06	An Integrated Strategy for Underground Facilities and Infrastructure	Laura Baudis Kevin Lesko	Jeter Hall John Orrell		Early Career Pietro Giampa William Thompson

UF Topical Areas

- UF1 – Neutrinos
  - Accelerator-based Neutrinos
    - e.g., LBNF/DUNE, Hyper-K
  - Non-accelerator Neutrinos
    - e.g., Supernova, solar, atmospheric, background ν's
  - Neutrinoless Double-Beta Decay
    - Nuclear Physics in US, but large HEP & UG overlap
- UF2 – Cosmic Frontier
  - Direct detection of dark matter in underground locations
- UF3 – General Underground Detectors
  - e.g., New technologies, R&D/small-scale exp., QIS, gravity

UF Topical Areas

- UF4 – Supporting Capabilities
  - Low-background methods, cryogenics, other supporting… not necessarily UG, but needed for UG experiments
- UF5 – Synergistic Research
  - Non-HEP UG science: Geo., Bio., Eng., Nuc. Astro.
- UF6 – Integrated Strategy for UF&I
  - Working group for a vision going beyond a gap analysis

Focus of Underground Facilities Group

- Understand current and planned underground facilities, underground space for experiments, and supporting capabilities
- Develop requirements and wishes for the future experiments and in particular new frontiers (e.g. QIS)
- Develop synergistic relationships among experiments (shared space, parallel use, partnerships, shared technology)
- R&D space and growth of new technologies
- Understand underground space requirements in closely related fields (nuclear astrophysics, $0\nu\beta\beta$, ...)
- Create a vision for underground facilities in the coming decades

Session #115

Neutrinos, dark matter and underground facilities

Session organizers from NF/CF/UF: Hugh Lippincott (moderator), Tim Bolton, Patrick Decowski, Alvine Kamaha, Brianna Mount, Gabriel Orebi Gann, Danielle Speller

Panel discussion

Panel discussion of needs for underground facilities for future neutrino and cosmic frontier experiments

Panelists included both science and facility experts:

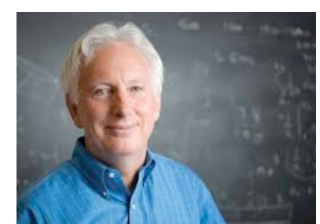
- Mary Bishai, BNL (DUNE)
- Laura Marini, UC Berkeley (CUORE)
- Elaine McCluskey, FNAL/SURF (LBNF/DUNE)
- Sean Paling, Boulby Director
- Kim Palladino, Oxford (LZ)
- Nigel Smith, SNOLAB Director
- Bob Svoboda, UC Davis (ANNIE, AIT/NEO, SNO+, DUNE)

- Great community turnout: 110 participants, active discussion, many questions









Session #115

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Session summary

- Desired outcomes from Snowmass
  - Communication and coordination across the community and between labs
  - Support for full realization of US-based facility at SURF, including 4 DUNE modules and a broad range of smaller projects
  - Opportunity to bring in a different technology for the 4th module if it meets DUNE physics goals
- Balance of small- and large-scale projects
  - Strong support for smaller-scale projects
  - Labs set up to accommodate them, enthusiastic to provide support
  - Important to balance rapid turnaround of science and development with longer-term planning needed for larger projects
- Options and science need for greater depth or other expansion
  - SNOLAB have explored option for a 4th cavern, positive news for hosting another large experiment
  - SURF exploring the possibility of 7400 level, part of a long-term vision
- Importance of a safe and conscientious underground working environment
- Benefit of a community-driven coordinated approach to low background assays and other general resources & facilities

UF01 Topical Conveners and Liaisons:
Tim Bolton, Patrick Decowski, Danielle Speller, Gabriel Orebi Gann, Albert De Roeck

UF01: Underground Facilities for Neutrinos

A Few Points from Discussions

Critical area of research
- Continued concentration on the science drivers for $0\nu\beta\beta$ and neutrino studies - they are many
- Multiple experiments/technologies running, planned, and in discussion

International Involvement
- Many experiments international
- Interest from labs like Boulby, internationally, in hosting, and to understand what needs there are and how they can be met

Emphasize US potential
- Discussion of push for concentration on SURF as major US-supported underground facility during Snowmass
- Eg. Plans for 4 SURF caverns, 2 nearly funded. Should really think about how to take advantage of facility; new things will come up as progress on the science and would be short-sighted to stop at 2 caverns. Possible opportunities for next generation/future ton-scale experiments

Availability of Facilities
- Not a zero-sum game. Room for multiple scales/sizes/types of experiments
- Do we have enough space to support the community?
- Do we have a large enough community to support the underground space we have?
- Right now not really space limited. Major experiments get large share of planning focus because of time, energy, and funding required; but small experiments welcome and important

Emphasis on increased coordination and engagement

- This is the time to really push on developing coordination and framework for supporting communication between facilities and between labs and facilities
- Benefit of a community-driven coordinated approach to low background assays and other general resources & facilities
- Support – technical, computing, infrastructure, but also project management and scientific support – is key

UF01 Topical Conveners and Liaisons:
Tim Bolton, Patrick Decowski, Danielle Speller, Gabriel Orebi Gann, Albert De Roeck

Moving Forward with UF01

Key Questions

- What are the **primary needs** of current and funded/planned experiments?
- What are the **dreams for the future** – what are the ideal resources and facilities for these experiments? What does the science require, in terms of numbers (background levels, cleanliness, depth, etc) and community effort/contribution, to achieve
    - Sensitivity?
    - Complementarity?
    - Replicability/Confirmation of discoveries?
- **Would these ultimate dream experiment(s) be limited by facilities** or by some other source of backgrounds?
- In the case of **shared space/resources, what experiments are compatible** with e.g., $0\nu\beta\beta$ requirements and infrastructure?
- What facilities are equipped to host future $0\nu\beta\beta$ experiments in the event of expansion?

Next steps

- Interface with the ***Supporting Capabilities Topical Group*** to understand what the current underground facilities capabilities are, what the needs are from the survey, and whether there are matches/mismatches.
- Contact collaborations to ***gain an understanding of the ballpark infrastructure, cleanliness, and space requirements for upgrade and next generation experiments***, and ***constraints on compatible experiments that could share space/infrastructure***
- Discuss a future ***UF joint topical workshop*** to have people available in real-time to discuss these questions

UF02: Underground Facilities for Cosmic Frontier

UF02 Topical Conveners: Scott Hertel, Kaixuan Ni, Emilija Pantic, Hugh Lippincott, Jodi Cooley, Eric Dahl

Underground F&I Needs for Large (>10 tonnes) Liquid Xenon Experiments

Current and Future Experiments using Natural Xenon for Dark Matter, Astrophysical Neutrinos, Neutrino Properties etc.

Experiment	Active Target	Current Status	Underground Lab	Detector+Shield Space	Infrastructures
PandaX-4T	4 tonne	Commissioning	CJPL	10m (D) x 13m (H) water tank	individually developed cryogenics, gas-storage, purification, radioactive-control systems
XENONnT	6 tonne	Commissioning	Gran Sasso	10m (D) x 10m (H) water tank	
LZ	7 tonne	Commissioning	SURF	GdLS OD inside 8m (D) x 6m (H) water shield	
DARWIN	40 tonne	R&D, CDR 2021	Gran Sasso	reuse/upgrade XENONnT's or new	upgrade XENONnT's
PandaX-xT	30-100 tonne	Planning	CJPL	reuse PandaX-4T's	upgrade PandaX-4T's
G3-LXe in US	40-100 tonne	Planning	SURF?	new space needed?	upgrade LZ's

Snowmass Letters of Intent:

- Particle dark matter searches with a G3 liquid-xenon detector
- The Sanford Underground Research Facility
- The PandaX Experiment
- Dark matter physics with the DARWIN Observatory
- The exploitation of Xe Large Scale Detector Technology for a Range of Future Rare Event Physics Searches

The world community needs at least one, but not more than two, of these large liquid xenon detectors, to probe DM down to the "neutrino floor" and to search for many other rare event signals.

UF02: Underground Facilities for Cosmic Frontier

UF02 Topical Conveners: Scott Hertel, Kaixuan Ni, Emilija Pantic, Hugh Lippincott, Jodi Cooley, Eric Dahl

low-mass DM

Clarification: thinking here about keV-MeV DM masses (rather than 'ultra light' wave-like)

Rapidly evolving 'new' field.

Boundary between R&D and 'experiments' not always clear

(some R&D occurs underground, some DM exposures occur above ground)

Diverse in technology and facilities/infrastructure requirements.

Compared to WIMP/0vbb, low-mass DM projects typically smaller in footprint and perhaps exposure time.

Low-mass DM projects can take advantage of a *diverse spectrum* of experimental sites

diverse in depth/access, cleanliness, vibration, vertical height, …

small target masses (1g to ~10kg) *may* significantly reduce depth requirements for *some* detector technologies

Overlap with other science goals: not *just* the obvious WIMP/0vbb facilities overlap

1) Quantum computing: potential for shared QIS/low-mass DM facilities at shallow depth

- many low-mass DM technologies are also at mK temperatures, using the same dilution fridge foundation.
- perhaps a similar layer of overburden (100m scale) would benefit both fields
- a National mK User Facility is gaining broad support, may include shallow underground component

2) Underground gravitational wave facilities, potential for 'parasitic' use of such a facility

- low-vibration underground space (similar to Einstein telescope) may also be key to some DM technologies

Low-mass DM may benefit from some centralization of future calibration efforts at dedicated facilities

- one example: a very low-energy (<keV) neutron scattering facility (to calibrate meV-eV scale nuclear recoils)

UF03 & UF05: Underground Detectors & Synergistic Research

UF03 & UF05 Topical
Conveners and Liaisons
Laura Cadonati,
Maurice Garcia-Sciveres,
Dan Robertson

Gravity - 2 kinds of needs

1. **Gravitational wave ground-based interferometry (Einstein Telescope)**

- Third generation of gravitational wave detectors: Cosmic Explorer (US, above ground) and Einstein Telescope (underground). Preliminary design includes ~130 km of tunnels, 6.5 m diameter, 3 corner stations.
- Will be based in Europe - existing MoU with CERN on instrumentation
- Planned depth of ~100m to mitigate anthropogenic seismic noise
- Natural synergy:
    - Einsten Telescope will require technologies that are already developed for particle physics: underground construction, cryogenic technology, advanced controls
    - The GW community offers expertise in vibration control that can benefit other experiments that require vibration control

1. **Microgravity/interferometry/tests of General Relativity (a range of projects)**

- Many gravity experiments that can benefit from underground facilities: microgravity experiments that benefit from long (km-scale) free-fall, tests of GR with precision gyroscopes [e.g. GINGER at LNGS], short-distance gravity tests, atom interferometry [e.g. MAGIS], matter wave interferometry, Dark Matter and Axion Searches with AMO Physics Techniques
- Benefit generically from underground facilities with:
    - Long vertical baseline/free-fall distances (km-scale)
    - Seismic isolation / low gravity gradient noise
    - Environmental stability (vibration / temperature)
    - Reduced cosmic ray flux

UF03 & UF05: Underground Detectors & Synergistic Research

QIS/QC

One of the challenges for quantum computing are decoherence errors - Decoherence errors caused by cosmic rays (and other ionizing radiation) in some quantum computers (e.g. superconducting transmon qubits).

Early days of understanding these kind of errors. If underground will be required at all and if so what depth still TBD.

Near term: R&D capabilities (dilution fridges underground)
Long term: Underground quantum data centers

Potential:

- Could attract industry partnership
- Dual-use of sensing experiments

UF03 & UF05: Underground Detectors & Synergistic Research

Additional opportunistic science underground

Multi-disciplinary projects (bio + geo-engineering) are useful both for shared skills/facilities, and funding opportunities.

Microbiology

- Existing facilities: Beatrix gold mine (South Africa), Moab Khotsong gold mine (South Africa), SURF (SD, USA), Kidd Creek Deep Fluid/Life Observatory (Canada), Boulby Mine (UK), Aspo Hard Rock Laboratory (Sweden)
- Facility requirements:
  - Novel/extreme geochemical environments
  - Ground water uncontaminated (by surface water)
  - Extended access for in-situ studies, distributed sample sites
  - Safety

Geology/geological engineering

- Key interest: Diverse, distributed sites to understand variety of underground environments (varying permeability/porosity/temperature/stress/chemistry). Multiple small sites (both in multiple facilities, and distributed/isolated within a facility) are more useful than large sites.
- Facility needs: Power, water, ventilation, ground support, logistical support

UF03 & UF05: Underground Detectors & Synergistic Research

Additional opportunistic science underground

Multi-disciplinary projects (nuclear) are useful both for shared skills/facilities, and funding opportunities.

Nuclear Astro.

- Existing facilities:
  - SURF-CASPAR (SD, USA): DIANA upgrade proposal under review
  - Gran Sasso-LUNA / LUNA-MV (Gran Sasso, Italy): LUNA-MV upgrade under construction
  - Jingping Underground-JUNA (Jinping, China): Under construction
  - Possible system in ANDES, South American joint venture - Review process
- Requirements:
  - Facilities are often small and isolated (preferred) with lower requirements for facility interaction
  - Extended access requirements for long running campaigns - Shared requirement with multiple disciplines
  - In-situ utilities - Connectivity, power, cooling, climate control and local support - Shared requirements
  - Due to the nature of generating accelerated heavy ion beams, some level of separation and isolation is required to ensure the integrity of other programs underground

UF03 & UF05: Underground Detectors & Synergistic Research

UF03 & UF05 Topical
Conveners and Liaisons
Laura Cadonati,
Maurice Garcia-Sciveres,
Dan Robertson

Moving forward

- How can we maximize synergies for small experiments as new large facilities are built?
  - Keep these communities connected to the sites, as facilities are designed/built/expanded
  - Bio benefits more from new sites than expansions of old sites. GeoEng may also, depending on geography
  - Nuclear astro. can greatly benefit from older site renovations in “remote” cavities
- Overlap between Einstein Telescope facility needs and other gravity experiments:
  - Similar concerns regarding environmental/seismic isolation, and needs for other facility users not to disturb that environment. So they are fundamentally compatible
  - Different needs: Vertical free-fall needs (MAGIS) vs horizontal run needs (Einstein)
- It would be useful to have an underground space rating/specification system. This is in part looking forward to scenarios where QIS drives industry to create new underground facilities that could be leased to scientists.
  - Include in Lab survey a list of capabilities that enable opportunistic science
- Combined with rating/specification system for underground space, would be beneficial to understand the limitations and restrictions of other proposed facilities.

UF04: Supporting Capabilities for Underground Science

UF04 Topical Conveners and Liaisons:
Alvine Kamaha, Brianna Mount, Richard Schnee

- Path Forward for Supporting Capabilities
  - An underground supporting capabilities survey has been created to this regards. Link here. It will be sent around shortly after the CPM meeting. The goal is to:
    - Collect supporting capability needs from current and future experiments through a survey
    - Collect current capabilities from existing facilities through a survey
    - Determine the mismatch between the two and what capabilities need further development.

UF04: Supporting Capabilities for Underground Science

- Summary of Ideas from Sessions – #115
  - Acknowledgement supporting techniques and facilities (like screening facilities) in UG laboratories need to be expanded.
    - Labs are ready to support this growth, but it depends on funding and on clear communication from experiments about their needs.
  - Ensure future experiments are aware of existing supporting capabilities (e.g. low background counting & radon emanation)
    - ... and that UG labs know needs of future experiments for expansion
    - Recommendation: Use Snowmass as trigger toward better facility coordination & communication between stakeholders
  - Think about common needs for small-scale experiments and not only for large scale experiments
  - DUNE 4th module represents an opportunity for a great new idea at much reduced cost

UF04: Supporting Capabilities for Underground Science

- Summary of Ideas from Sessions – #122
  - Two primary classes of underground needs
    - Shallow, usually for reduction of human-induced seismic vibrations
      - » Einstein Telescope (laser interferometry gravity wave detector)
        - Interest in borrowing from accelerator beamline expertise
      - » Perhaps a role in QIS developments
      - » Such experiments deemed too sensitive to share space simultaneously, but could benefit from using the same (very expensive) hole at different times
    - Deep, usually for reduction of cosmic rays
      - » Dark matter, neutrinos, nuclear astrophysics, maybe QIS eventually
      - » Experiments needing long freefall distance
  - Synergist research in underground facilities:
    - Microbiology, geophysics, geological engineering all benefit from underground facilities for other uses
      - » Generally no conflicts with other uses
      - » Synergies can pop up; communication is key to maximize these (e.g. biology taking advantage of DUNE excavation at SURF)
    - Nuclear astrophysics could benefit from low-background and cleanliness facilities for DM, nu, but also has potential conflict of creating radiation undesirable to those experiments

Summary & UF&I Steps Forward

- Underground Facilities & Infrastructure is one of the smaller Frontier areas in Snowmass…
  - We have good engagement & room for contributors!
- UF&I is seeking to document needs and create a vision for maintaining and executing future underground science
- Our methods will include:
  - Engaging with other Frontiers via workshops & meetings
  - Surveying UG Laboratories & Scientific Collaborations
    - Record existing infrastructure, determine needs, identify gaps
    - Develop a community-consensus vision for the future of underground facilities to support a broad science program
- UF&I has been challenged to consider broadening our engagement within the HEP community and consider how UG labs can be visible HEP-ambassadors for public outreach

BACKUP MATERIALS

2013 Underground Facility Report and Recommendations: [1401.6115]

15 pages

2 page summary

Short bulleted list of physics goals

Specific section for large detectors

Specific section on low background assay

Simple timeline of facilities & experiments

Specific table for *large* experiments

Summary of assay needs

Summary of existing infrastructure

Recommendations/Conclusions

1. Locate LBNE underground to realize its full science potential. This step would also provide a natural base for additional domestic underground capabilities at SURF in the future.
2. The U.S. has leading roles in many of the future dark matter, neutrinoless double beta decay and neutrino experiments.
3. More coordination and planning of underground facilities (overseas and domestic) is required to maintain this leading role, including use of existing U.S. infrastructure and closer coordination with SNOLAB as the deepest North American Lab.
4. Maintaining an underground facility that can be expanded to house the largest dark matter and neutrinoless double beta decay experiments would guarantee the ability of the U.S. to continue its strong role in the worldwide program of underground physics.

2021 Underground Facilities Report

The Underground World has progressed markedly since 2013. Much of the exciting physics opportunities in the coming decades will be underground. A number of physics topics have made progress since 2013: LBNE/DUNE, G2 Dark Matter, Nuclear Astrophysics, Low Background Assay, …

We should assemble a more comprehensive report for Snowmass 2021.

Each topic should include at least (suggested lengths):

1 - 3 pages: progress since 2013, current experimental situation and status worldwide and within the US and/or with US participation.

2 - 5 pages: forward looking goals, what will the next 10 - 20 years offer US HEP Physics

2 - 5 pages: what will these goals **require from u/g and supporting facilities**. If firm plans exist for hosting experiments - indicate this.

0 - 5 pages: explore opportunities for cooperation and synergistic approaches

Provide a high level technically-limited estimate of the schedule

Indicate alignment with 2013 P5 & Snowmass recommendations

2021 Underground Facilities Report

With these inputs, we will assemble:

- Executive Summary
  - Physics goals for the coming 10 - 20 years
  - Recommendations
- Gap analysis for infrastructure
  - What exists (worldwide)
  - What will be needed for this program
  - Plans or proposals to provide the infrastructure
  - Discussion on the US program in particular
- A *visionary plan* for US Underground Physics Program

A Community Planning Process

- Letters of Interest (LOIs)
  - Only seven specifically flagged for UF (below)
  - We will review other LOIs for UF-relevant topics

1. KURF The Kimballton Underground Research Facility
2. The Sanford Underground Research Facility
3. Advanced Germanium Detectors and Technologies for Underground Physics
4. Classification standard for underground research space
5. Development of the Boulby Underground Laboratory in the UK into a facility to host major international rare event searches
6. Solution-mined salt caverns as sites for underground
7. An Ultralow Background Facility to Support Next Generation Rare Event Physics Experiments

Community Planning Meeting (CPM) – Oct. 2020

Tuesday Oct. 6

- 7. UF Intro
  - 11:00 AM (**US/Central**)
  - Orrell, Lesko, Baudis, Hall
- 77. Quantum Sensors for Wave and Particle Detection
  - 11:30 AM
  - Garcia-Sciveres, Jodi Cooley
- 122. Capabilities needed to execute underground experiments in a broad range of research categories
  - 1:00 PM
  - Schnee, Dahl, Garcia-Sciveres
- 118. Cross-community Mobility in Science
  - 1:00 PM
  - Hall, Orrell
- 51. Requirements for low background and underground detectors
  - 3:00 PM
  - Lippincott, Orrell

Wednesday Oct. 7

- 110. Baryon and Lepton Number Violating processes
  - 1:00 PM
  - Speller, Decowski
- 115. Neutrinos, dark matter, and underground facilities
  - 1:00 PM
  - Kamaha, Mount, Orebi Gann, Lippincott
- 207. UF Planning
  - 3:00 PM
  - Orrell, Lesko, Baudis, Hall

Overall Snowmass 2021 Timeline

Preliminary Snowmass Timeline / Process

Starting point for discussion with the community during CPM

Meetings & Workshops (10 Frontiers & 80 Topical Groups) + Contributed Papers

Nov. 2020	Dec. 2020	Jan. 2021	Feb. 2021	Mar. 2021	Apr. 2021	May 2021	Jun. 2021	Jul. 2021	Aug. 2021	Sep. 2021	Oct. 2021

Community Meeting
(APS April Meeting)

Community Summer Study (CSS)
July 11-20, 2021 + DPF 2021
(UW Seattle)

Snowmass
Report

TGs: effort on consolidation, coordination
& solicitation, leading to studies &
Contributed Papers

TGs develop their key questions and opportunities

TGs produce outlines of their reports

(TGs: communication with authors of Contributed Papers)

Frontiers/TGs produce Preliminary Frontier Reports
Community feedback on Preliminary Frontier Reports

CSS

Build consensus on key questions / opportunities of particle physics,
enabling technologies, community engagement;
Formulate the content of Executive Summary

Frontiers/TGs produce Final Frontier Reports
Steering Group produces Preliminary Executive Summary
Community feedback on Prelim. Exec. Summary
Snowmass Draft Report and Review
Snowmass Final Report

Proposed UF Timeline

Underground Facilities Frontier Plan (DRAFT)

- Sep 2020 - Jul 2021: Participate in Scientific Frontier workshops, town halls, and breakouts. Arrange and participate in key scientific breakout sessions on topics with high impact or new opportunities for underground facilities and infrastructure. UF/I does not foresee holding distinct workshops, but participating in the Scientific Frontiers efforts.

- August - September 2020: White Paper Outline, LOI sorting, Participation in CPM workshops, etc.

  - Invite remaining co-conveners and liaisons, hold organizational meeting ✓
  - Establish outline and major chapters of White Paper ✓
  - Sort, organize and condense LOIs into White Paper Work Groups (WPWG) include additional topics from convener and co-conveners organization
  - Organize Participation by UGF members in CPM breakouts
- October 2020: CPM
  - 5 - 8 October: CPM
  - Mid-October: Assemble UF/I Conveners and Liaisons Debriefing Session: assemble key points and lessons from CPM
  - 30 October: Assemble and vet solicitation lists, establish contacts, finalize facility and infrastructure questionnaires
- November - January
  - solicit input from Facilities, Collaborations, and R&D efforts
  - 15 January: Draft Existing Supply and Projected Needs Analysis (UF/I Gap Analysis)
  - Begin work on U/FI Visionary Plan
- White Paper Draft Timeline
  - Draft Outline; ✓
  - 15 February: **White Paper 1st Draft** *sans* Visionary Plan (focus on supply and projected needs)
  - 15 March: **Community and Facility comment period**
  - 15 April: **White Paper 2nd Draft**, (include initial draft of Visionary Plan)
  - *APS meeting:17-20 April*
  - 20-30 April: 2nd draft **Community and Facility comment period**
  - 15 June: **White Paper 3rd draft** of U/FI report:
  - 15 June - 1 July: 3rd **Community and Facility comment period**
- Snowmass in Seattle: 11-20 July 2021
- Final white paper deadline: 31 July 2021
- Final U/FI report: 1 September 2021
- Final Snowmass report: 1 October 2021
- 2 October, celebrate completion of report